USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Effectiveness of Remotely-Sensed Lineaments and Outcrop-Scale Fractures in

Identifying Bedrock Aquifers in New England

Duration: 9/96 to 9/98

Federal Funds Requested: $38,018

Non-Federal Matching Funds Pledged: $76,404

Principal Investigator: Stephen B. Mabee, University of Massachusetts

Congressional District: 1 st Congressional District

Project Summary

The spatial extent and physical characteristics of bedrock discontinuities are primary factors controlling the storage and movement of groundwater in fractured rock. Obtaining a firm grasp of the three-dimensional geometry and hydrology of fracture networks is critical to understanding contaminant transport, designing effective remediation, or developing new water supplies. However, most of what is known about the fracture network in the subsurface comes from observations made at surface outcrops or in a few well-placed boreholes. It is a rare occurrence when researchers can make direct, "first-hand', observations from within the rock mass.

The Massachusetts Water Resources Authority is constructing a new water supply tunnel through eastern Massachusetts beginning in the summer of 1996. The 28 km-long tunnel will traverse three accreted geologic terranes at an average depth of 70 m below ground. This will provide a unparalleled opportunity to make detailed observations of fracture features and groundwater flow conditions in the subsurface. Measurements made in the tunnel will provide a unique database of fracture information against which surface geophysical, borehole, geochemical, remotely-sensed lineament and outcrop-scale fracture data can be rigorously compared.

The purpose of this proposed research is to: 1) document the location, orientation, physical characteristics, and approximate yield of water-beating discontinuities within an initial, 10-15 km section of the tunnel; and, 2) use these measurements to; a) assess the reliability of using remotely-sensed lineaments to predict zones of high groundwater yield within the bedrock, and, b) compare the geometry and physical characteristics of fracture features observed in surface outcrops with those observed in the tunnel. Results of this work will not only quantify the relationship between lineaments and subsurface fractures but will also evaluate whether or not fracture characteristics observed in surface

outcrops can be extrapolated into the third dimension with any degree of certainty. The University of Massachusetts has already obtained permission to access the tunnel during the entire 5-year construction phase.

Statement of Regional Need for Research

Growth and development in the northeast arc placing high demands on groundwater resources. Many of the areas experiencing this growth rely on bedrock wells to meet potable water supply demands, particularly in rural New England communities. For these reasons, bedrock aquifers are considered important and areas possessing high-yield potential must be identified and protected. However, planners, state agencies, and individuals who must make decisions regarding aquifer management and protection or who must establish siting criteria for landfills and other water quality-threatening facilities need guidance in identifying and evaluating important bedrock aquifers.

Lineament analysis of remotely-sensed imagery remains one of the most commonly used reconnaissance tools for assessing potentially transmissive zones in the bedrock. The technique used for both region-wide studies and small-scale site investigations. However, the method is inherently subjective (Siegal, 1977; Podwysocki and others, 1975; Wise, 1983a) and certainly not all lineaments guarantee finding highly transmissive discontinuities in the bedrock. Despite these shortcomings, the method continues to be used by hydrogeologists even though no significant advancements have been made to improve the predictive capability of lineament analysis since the connection between lineaments and groundwater was first established by Lattman and Parizek (1964). The fundamental problem with the lineament analysis technique is that no one has been able to associate lineaments with specific water-beating fractures in the subsurface. This project will provide a unique opportunity to acquire tangible evidence from the subsurface that will quantify the relationship between lineaments and water-bearing discontinuities in the bedrock. It will also provide an opportunity to explore some of the other geologic factors that may influence, as well as improve, the predictive capability of the method.

Statement of Regional Benefit From the Results of this Project

Direct benefits expected as a result of this research project include: 1) verification of the reliability of the method as a tool for predicting high-yield fracture zones in the bedrock; 2) quantification of some of the other geologic factors that may control the usefulness and reliability of the method as a predictive tool, for example, structural setting, bedrock type, proximity to surface water bodies, type and thickness of overburden, fracture characteristics such as spacing, planarity, trace length, etc.; 3) development of a framework for cataloguing lineament and fracture data on a regional scale; and 4) development of a lineament mapping protocol for delineating possible high-yield fractured-bedrock aquifers on a state or regional level.

Regional planners, state agencies and other individuals will be given a methodology that will allow initial preparation of maps and overlays indicating the location of important

bedrock aquifers. These maps, which can easily be incorporated into GIS applications, will provide planning guidance for remediation programs, aquifer management and protection, and siting criteria for facilities and land uses that may threaten groundwater quality. Although this project is situated in Massachusetts, the results will benefit, in particular, the entire New England area since this region shares a common geologic heritage and shares the same desire to identify bedrock aquifers with greater reliability.